Improved Understanding of the Processes Controlling Tropospheric $O_3$ and $CO_2$ from Space-based IR Retrievals

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Processes Influencing the Global Distribution of Tropospheric $O_3$

Improved understanding of the processes influencing the global distribution of tropospheric $O_3$ is needed for better prediction of air quality and for quantifying climate change.
Inverse Modeling of CO

Satellite observations of CO suggest greater emissions of CO in winter than a priori inventories in North America and East Asia.

Season variation in top-down emissions, with greater wintertime emissions, is in agreement with previous work by Kopacz et al. (2009), but regional total are different.
Inverse Modeling of CO Using Multiple Trace Gases

Assimilation of TES O₃, MOPITT CO, and OMI NO₂ Nov 2-15, 2009

- Integrating TES O₃ and OMI NO₂ produces larger source estimates in the extratropics (particularly East Asia)
- With TES O₃, the reductions in CO emissions in South Asia are enhanced

[Keller et al., in prep]
Inverse Modeling of CO Using Multiple Trace Gases

Assimilation of TES O$_3$, MOPITT CO, and OMI NO$_2$ Nov 2-15, 2009

- Assimilating data from only one instrument produces a posteriori BB estimates that are sensitive to the prior

- For North Africa, assimilating all instruments provides sufficient information to strongly constrain the source estimate

- For South Africa and northern Australia, the a posteriori emissions are sensitive to the prior even when assimilating multiple instruments

> Optimizing these weaker sources may require a longer assimilation window

[Keller et al., in prep]
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Impact of Lightning NOx Emissions on O$_3$ Over North America

Modeled O$_3$ Over North America along 40°N

- The upper tropospheric ozone maximum is linked to NOx emissions from lightning, which were 0.068 Tg N for North America (in August), a factor of 4 lower than recommended by Hudman et al. [JGR, 2007] based on comparisons of the model with aircraft data.

- Assimilation increased upper tropospheric ozone over the southeast by 11 ppb, in agreement with the estimate of 10 ppb from Hudman et al. [JGR, 2007] for the enhancement in upper troposphere ozone due to lightning NOx.

[Parrington et al., JGR, 2008]
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Satellite Constraints on background $O_3$

- Assimilation of TES corrected the underestimate in $O_3$ in the model (due to lightning NOx emissions)
- Without assimilation the model underestimated background ozone by as much as 9 ppb (in western North America)

[Parrington et al., GRL, 2009]
Free tropospheric CO$_2$ data provide constraints on surface fluxes of CO$_2$ that are complementary to those from the surface observing network.

[Nassar et al., ACP, 2011]
High-resolution inverse modeling of TES and GOSAT CO₂ for 2010

- TES and GOSAT Flux estimates for Europe and boreal Asia are consistent
- TES suggest a weaker sink in Temperate Eurasia and Tropical Asia
- Flux estimates from TES are biased low for Temperature North America and Tropical South America, reflecting the influence biases in TES CO₂ in the subtropics

[Feng Deng, U. Toronto]
Impact of TES CO$_2$ over the Asian Monsoon Region

TES assimilation enhances CO$_2$ in the Asian monsoon anticyclone